

## *A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry (Brief)*

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## A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry

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Environment



# Outline

- Objective
- Simulation Framework
  - Architecture
  - MATLAB GUI
  - Tunable Parameters
  - Channel Models
- Link-Dependent Adaptive Radio
- Simulation Results
- Conclusion and Future Work



# Objectives

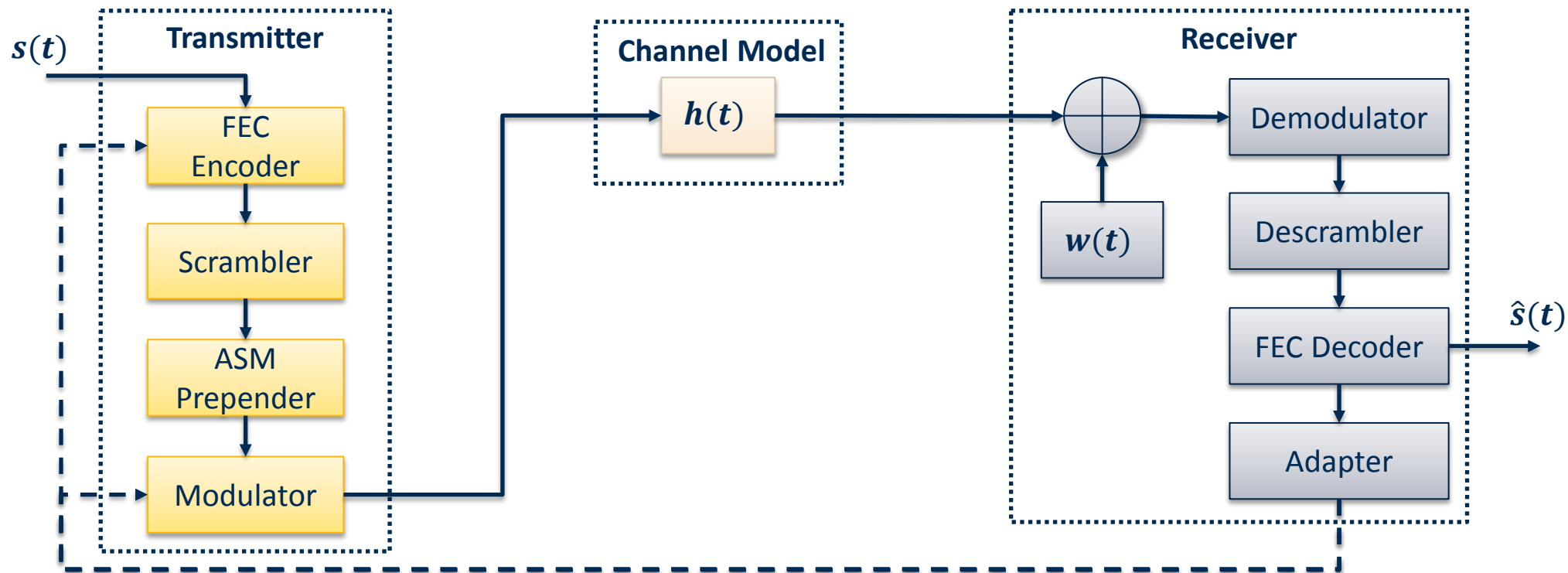
- **Simulation Testbed**

- Develop a simulation framework with adaptive input parameters
  - Apply to many research questions involving airborne telemetry applications

- **Link-Dependent Adaptive Radio**

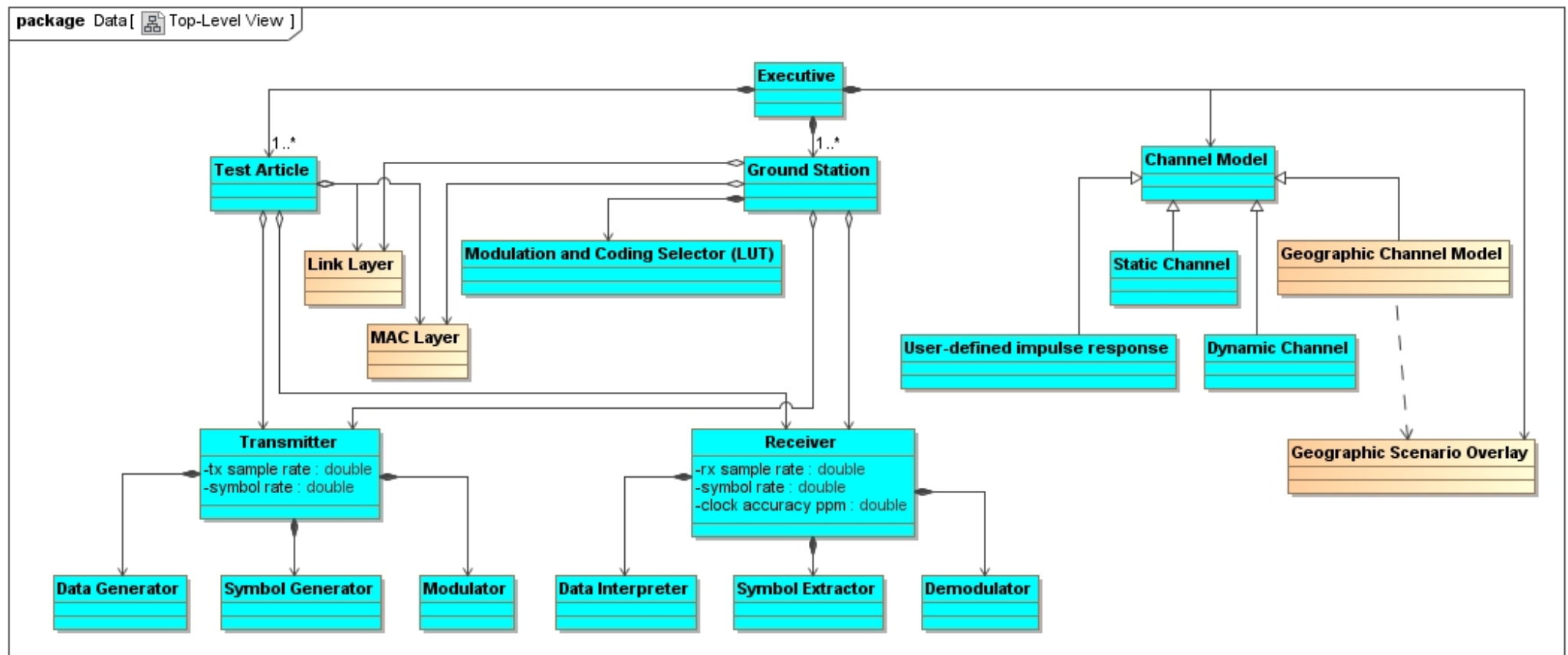
- Develop and test a prototype system that adapts its modulation/coding scheme based on channel conditions
  - Create a set of rules based on various channel models
  - Choose a transmission mode to maximize throughput while maintaining link reliability
  - Demonstrate adaptivity in simulation environment

# System Model



# Simulation Framework Architecture

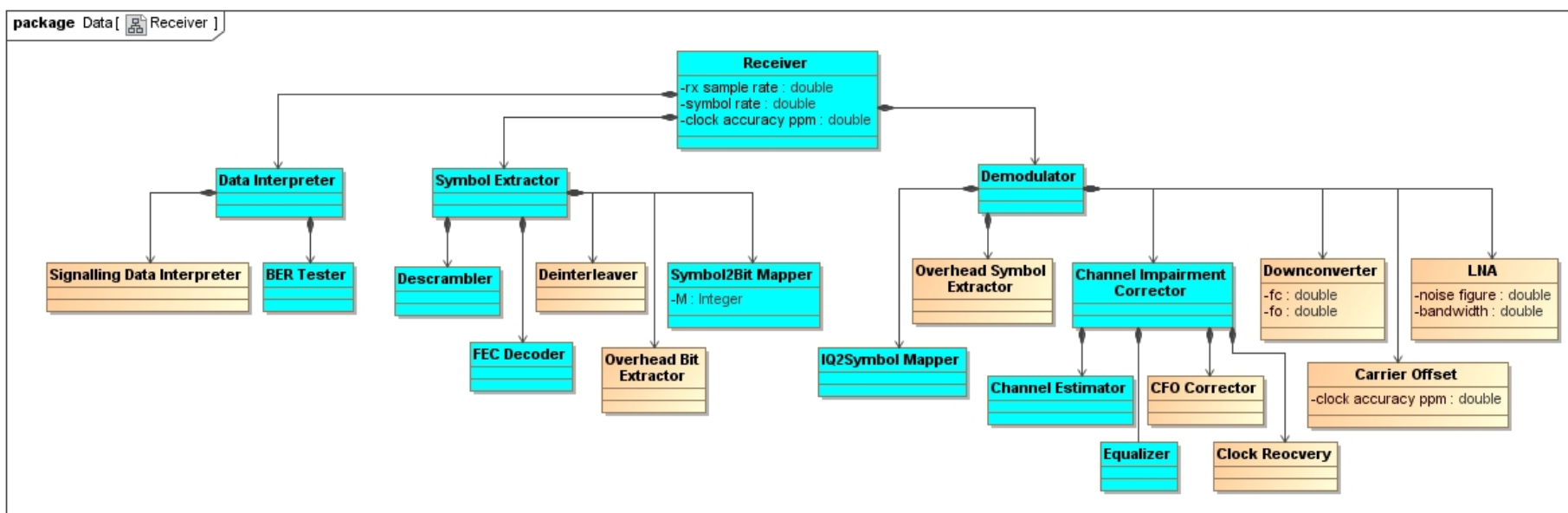
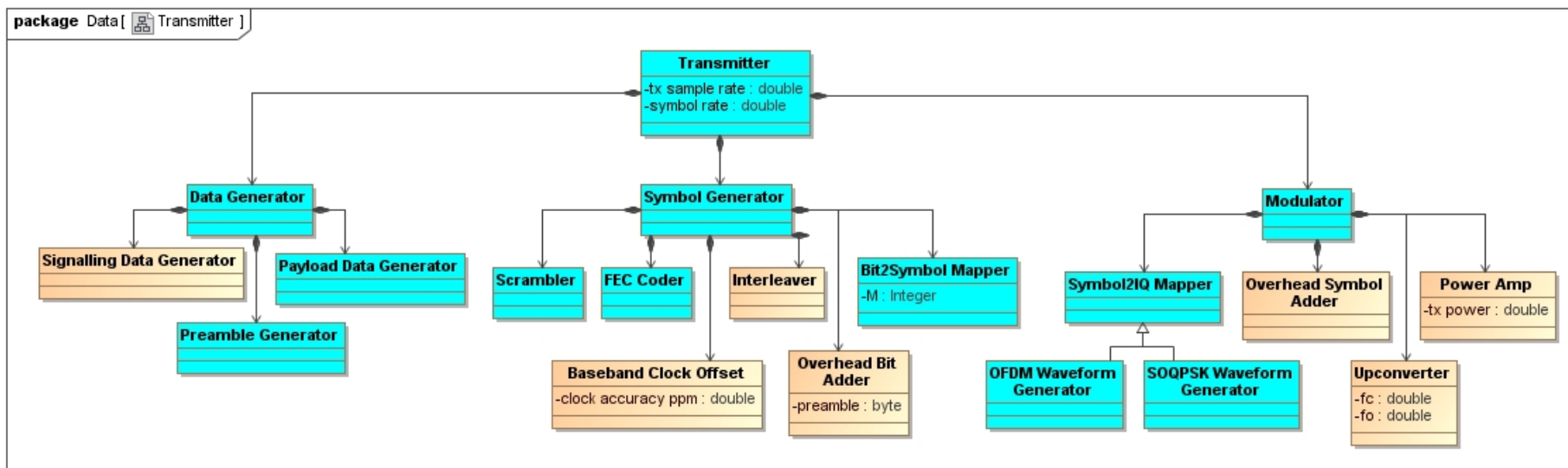
- Object-oriented MATLAB to maximize reusability and flexibility



Phase One

Phase Two





Phase One

Phase Two

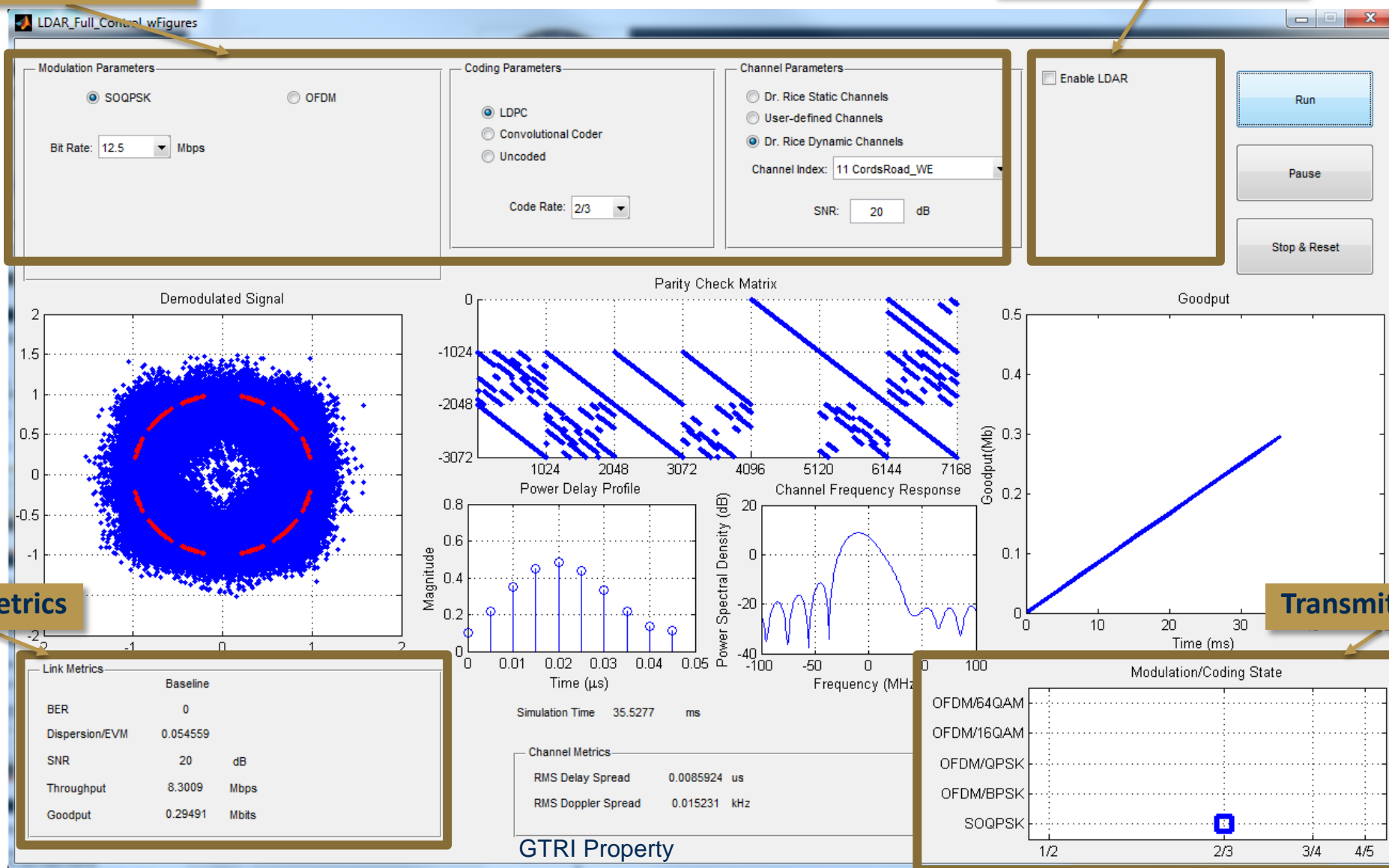




# MATLAB GUI Interface

## Input Parameters

## Application Selection



## Link Metrics

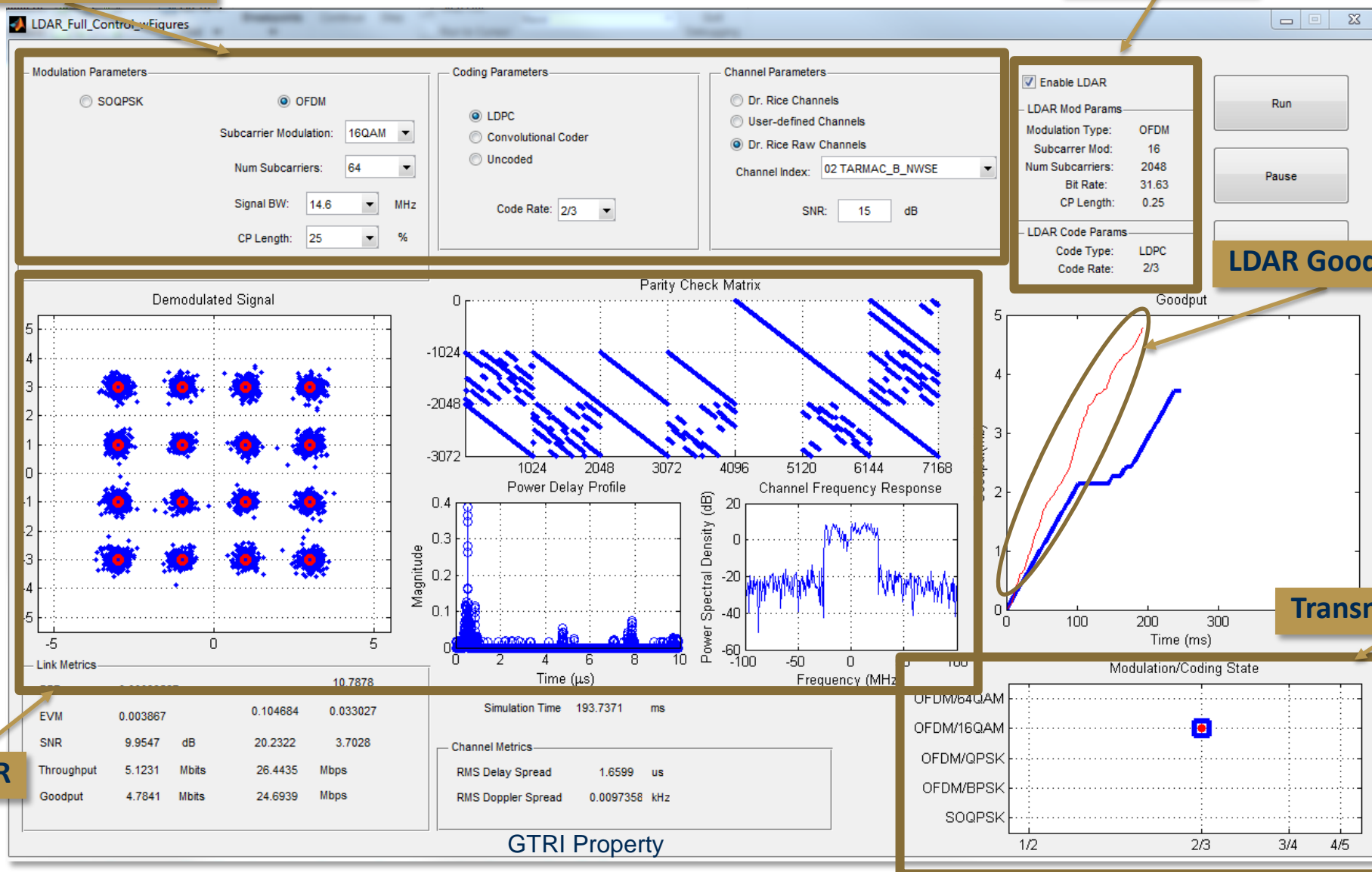
## Transmit Mode



# MATLAB GUI Interface

## Baseline Parameters

## LDAR Values



LDAR

LDAR Goodput

Transmit Mode



# Tunable Parameters

- Modulation
  - SOQPSK
  - OFDM (IEEE 802.11a)
    - Modulations: BPSK, QPSK, 16 QAM, 64 QAM
    - Cyclic Prefix Lengths
    - Number of Subcarriers
- Coding
  - LDPC
    - Rates: 1/2, 2/3, 3/4, 4/5

Modulation Parameters

☐ SOQPSK ☒ OFDM

Subcarrier Modulation: BPSK

Num Subcarriers: 64

Signal BW: 14.6 MHz

CP Length: 10 %

Coding Parameters

☒ LDPC ☐ Convolutional Coder ☐ Uncoded

Code Rate: 1/2

Channel Parameters

☒ Dr. Rice Channels ☐ User-defined Channels ☐ Dr. Rice Raw Channels

Channel Index: 1

SNR: 15 dB

☐ Enable LDAR

Run

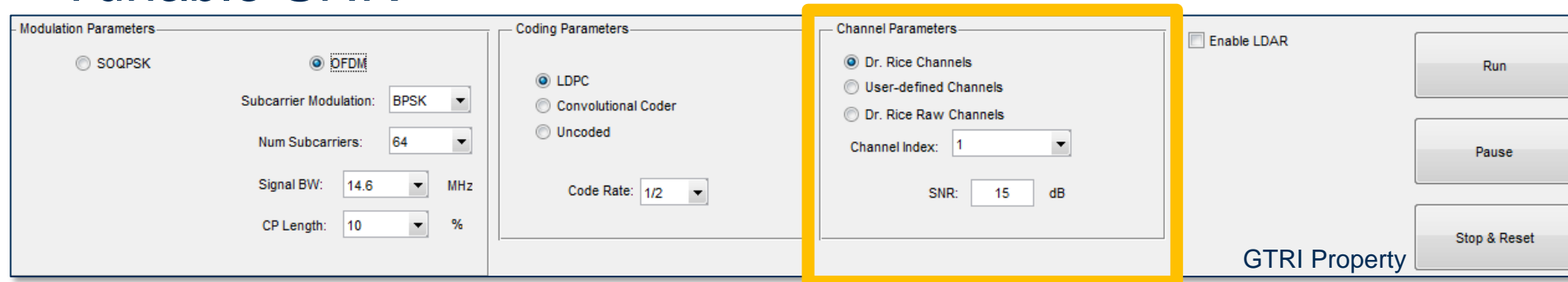
Pause

Stop & Reset

GTRI Property

# Channel Models

- Static
  - Representative channels from Dr. Michael Rice's collected data
- User-Defined
  - Arbitrary channel taps (mainly used for AWGN channel)
- Dynamic
  - Dr. Michael Rice's collected data from airborne channel sounding runs
  - We use these to reflect the dynamics of actual telemetry channels
- Tunable SNR

The screenshot shows the Channel Models software interface. It is divided into three main sections: Modulation Parameters, Coding Parameters, and Channel Parameters. The Channel Parameters section is highlighted with a yellow border. The Modulation Parameters section includes options for SOQPSK and OFDM, with OFDM selected. It also includes fields for Subcarrier Modulation (BPSK), Num Subcarriers (64), Signal BW (14.6 MHz), and CP Length (10%). The Coding Parameters section includes options for LDPC, Convolutional Coder, and Uncoded, with LDPC selected. It also includes a field for Code Rate (1/2). The Channel Parameters section includes options for Dr. Rice Channels, User-defined Channels, and Dr. Rice Raw Channels, with Dr. Rice Channels selected. It also includes a field for Channel Index (1) and a field for SNR (15 dB). On the right side of the interface, there are buttons for Run, Pause, and Stop & Reset, and a checkbox for Enable LDAR. The text "GTRI Property" is visible at the bottom right.



# Link-Dependent Adaptive Radio

- Empirically-based rule developed by GTRI
  - Collect data for each static channel
  - Create look-up tables for each static channel
    - Include values of EVM, Dispersion, BER, Throughput for various SNRs
  - Select a near-optimal transmission mode based on throughput and channel impairments
    - RMS Delay Spread
    - Error Vector Magnitude (EVM) for OFDM or Dispersion for SOQPSK

## LDAR Algorithm for Selecting New Transmission Mode

- 1: Compute the RMS delay spread of the current channel
- 2: Select a static channel that has the closest RMS delay spread as the representative channel
- 3: Look up the EVM/Dispersion value with the same transmission mode from the LUT of the representative channel
- 4: Select a mode with the highest throughput that has a BER lower than the threshold
- 5: Repeat Steps 1 to 4 for each delivered packet



# Simulation Results

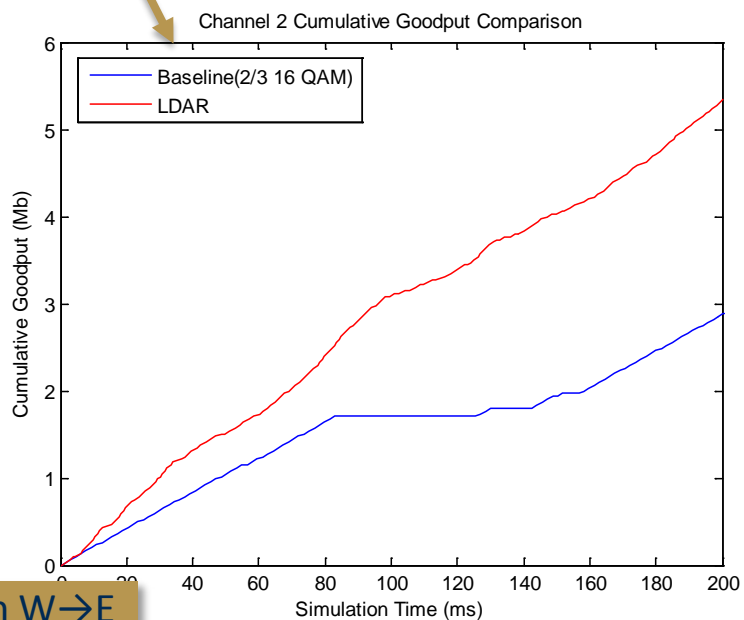
- Compare goodput performances between a baseline scheme and LDAR scheme
  - Baseline: 2/3 16-QAM OFDM
  - Burst Size: eight codewords
  - Fixed SNR: 15 dB
  - 11 Dynamic Channel Models

Dynamic Channel	Baseline Goodput (Mb)	LDAR Goodput (Mb)	Performance Increase (%)
1	4.0	5.2	30
2	2.9	5.3	83
3	0	4.2	N/A
4	2.0	4.4	120
5	4.0	8.2	105
6	0	8.1	N/A
7	3.3	4.4	33
8	0	3.7	N/A
9	3.3	5.2	58
10	4.0	8.8	120
11	4.0	8.4	110

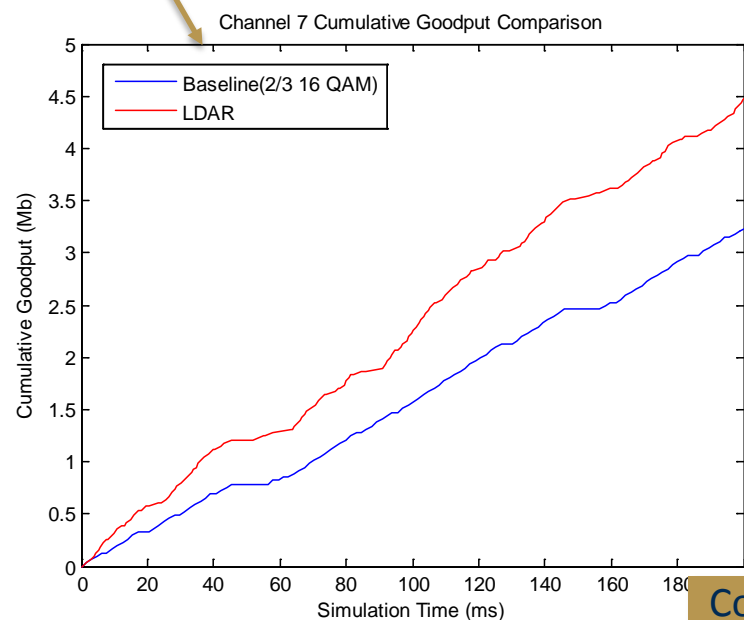




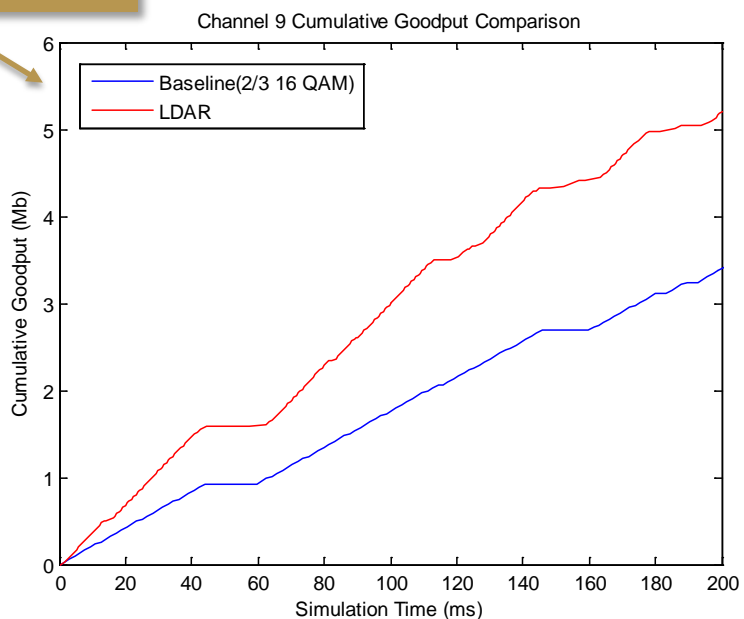
## TARMAC



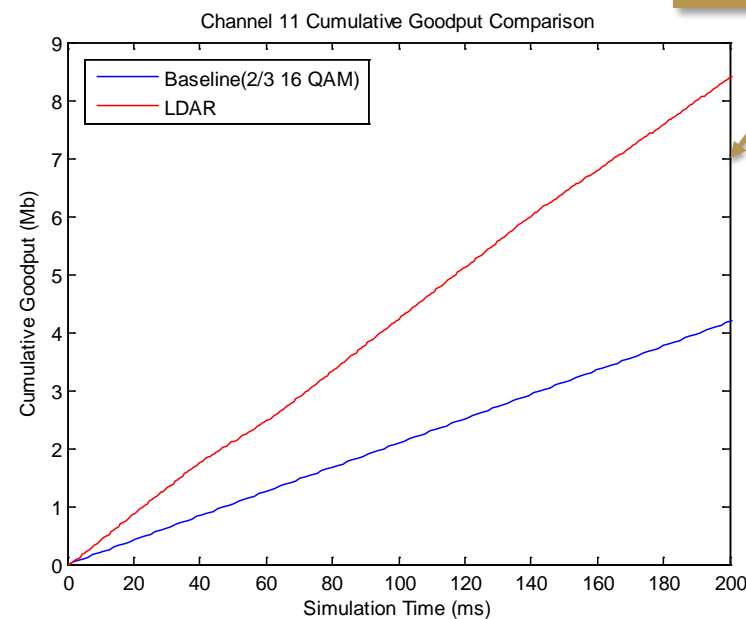
## Cords Road E→W



## Black Mountain W→E



## Cords Road W→E





# Conclusion and Future Work

- Developed a simulation testbed for aeronautical telemetry
  - Various Tunable Parameters
  - Example: Link-Dependent Adaptive Radio
  - Other Applications:
    - Tradeoffs of Phased Array Antennas
    - Utility of Multiple access schemes
    - Performance of Command and Control
- Future Work
  - Carrier Frequency Offset (CFO)
  - Doppler Shift
  - Convolutional/Turbo Encode
  - iNET Uplink
  - Mapping between EVM and Dispersion



# Questions?

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